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that in his view the fundamental factors in the business cycle are the price movement and the interest rate movement, the lag of the latter behind the former being responsible for the cycle. Fisher emphasizes the fact that the price cycle is the first and moving member of the business cycle. " A slight initial rise of prices sets in motion a train of events which tends to repeat itself. Rise of prices generates rise of prices, and continues to do so as long as the interest rate lags behind its normal figure."[1] In Fisher's view, however, the price cycle is not automatic. "The rise, culmination, fall, and recovery of prices . . . are abnormal oscillations, due to some initial disturbance. The upward and downward movements taken together constitute a complete credit cycle, which resembles the forward and backward movements of a pendulum."[2]

A view essentially similar to Fisher's, though much less fully worked out, is that of the English economist, Alfred Marshall,[3] who accounts for cycles (" alternating periods of prosperity and depression of commercial activity") by maladjustment between price and interest movements.

It will be seen that the quotations that have been given are by no means exhaustive. They do not pretend to be an epitome of all of the views held regarding the rôle of prices in the business cycle. German writers on the subject, of whom there has been a considerable number, are not cited at all. It should be said, too, that comparatively few of the several works mentioned represent the results of elaborate statistical research, and in no case (except by Moore for crop yields and prices) have correlation methods been applied to the data.

Our purpose in this note has been merely to indicate that, notwithstanding wide differences of opinion regarding the precise function of prices — as to their time relation to other elements in the cycle, as to the question of the automatic character of the price cycle, as to whether all prices or only some special prices are significant — the point of common agreement which stands out from all the diversity of views is that price movements are a significant, and in the minds of most writers the chief, characteristic of the business cycle. It is safe to say that for no other single element entering into the general business condition could such unanimity of opinion be demonstrated. Dr. Persons' analysis points to the same conclusion, that prices constitute the best single series with which to compare all other series, the best single " standard " or " index " of business conditions.

Concerning the special questions that have been raised, as to time sequence, what prices to use, and the like, the aim of the Review, as will have been apparent, is to arrive at its conclusions by independent analysis, rather than by attempting a synthesis of the views of other writers. It is clear from Dr. Persons' articles, in the January number and in the current number of the Review, that reliable conclusions regarding the time relation between different series must depend upon the use of more refined statistical methods, applied to finer time units, than have heretofore been attempted.

JOHN H. WILLIAMS.

The Line of Secular Trend

Mr. Edwin Frickey of the staff of the Review has worked out the following derivation and explanation of the slope of the line of secular trend. That explanation will be given for pig-iron production, 1903–16. The annual figures are as follows:

Year	Pig-iron Production Unit, 10,000 tons	Year	Pig-iron Production Unit, 10,000 tons
1903	1743	1910	2685
1904	1613	1911	2333
1905	2259	1912	2938
1906	2479	1913	3072
1907	2531	1914	2305
1908	1562	1915	2966
1909	2540	1916	3902

The object is to secure a measure of the average annual increase in pig-iron production. Let us first consider the extreme years 1903 and 1916; the increase in pig-iron production between these years was 21,590,000 tons, or an arithmetic average increase of 1,660,000 tons per year. But a mean of a single pair of years is not to be depended upon, for it is quite possible that the pig-iron production for one or both of these years might be extraordinarily high or low; such a mean is not apt to give a correct measure of the annual changes for the entire period. Let us now consider the pair of years adjacent to the extremes, i. e., 1904 and 1915. During this period the increase in pig-iron production was 13,530,000 tons, or a mean annual increase of 1,230,000 tons. During the period 1905 to 1914 (to take the next pair of years) the total increase in pig-iron production was 460,000 tons or an annual mean increase of 50,000 tons. It is quite evident that we shall get different figures for the mean annual increase, depending upon what pair of years we take as our basis of judgment. Let us, therefore, not base our conclusion on any one pair of years, but rather upon pairs of years which shall include all the different years of the time period in question. The following table shows the general average

(Units of 10,000 Tons)

Terminal years	The total increase in pig-iron production	The mean annual increase in pig-iron production	Number of years in interval	Weight assigned to average for this interval
1903 and 1916	2159	166	13	13×13=169
1904 and 1915	1353	123	11	11×11=121
1905 and 1914	46	5	9	9× 9= 81
1906 and 1913	593	85	7	7× 7= 49
1907 and 1912	407	81	5	5× 5= 25
1908 and 1911	771	257	3	3× 3= 9
1909 and 1910	145	145	1	1× 1= 1
General aver.	....	114.2	....	....

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[1] *The Purchasing Power of Money*, chap. IV, p. 60.

[2] *Ibid.*, p. 70.

[3] *Principles of Economics*, 5th ed., London, 1907, 1, p. 594 *et seq.*

annual increase in pig-iron production (in units of 10,000 tons) as indicated by the mean annual increase between the terminal years of specified time periods. The weights given in the last column were used to get the average given in the bottom line of the table. The method of computing that average will be explained shortly.

Now in taking the average of the various "mean annual increments between terminal years" we observe that these averages do not have equally wide bases. An average increase based upon the thirteen-year interval 1903–16, is obviously very much more trustworthy than an average based upon the three-year interval 1908–11, or, to take the extreme case, an average based upon the change over the single-year interval 1909–10. Let us, therefore, in averaging, weight each one of the average annual increments by the *square* of the number of years involved. This will have the effect of attaching relatively high importance to average annual increments based on the longer time intervals and relatively low importance to average annual increments based on the shorter-time intervals.

The average of the "mean annual increments between terminal years" based upon the various intervals of time, weighted as above described, comes out 1,142,000.[1] This gives us a single average figure which represents the average annual increase as indicated by the items for the *entire period*, 1903–16. It is obvious that precisely the same result would have been reached if a weighted average of "the total increase in pig-iron production" in the second column of the table had been computed using the weights 13, 11, 9, 7, 5, 3, and 1, respectively.

It may be demonstrated that the method of computing the annual increment outlined above is equivalent to that involved in fitting a straight line to data by the method of least squares.

Let us suppose that $y_1, y_2, \dots, y_n$ are the items of a time series for equal intervals of time. Suppose also that n is an odd number. Let x represent time measured from the center of the period. x will take the values

$$\left(-\frac{n-1}{2}, -\frac{n-3}{2}, \dots, -1, 0, +1, \dots, +\frac{n-3}{2}, +\frac{n-1}{2}\right).$$

The slope of the straight line fitted by the method of moments is $\frac{\Sigma xy}{\Sigma x^2}$. (See the January REVIEW, p. 12.) This expressed in terms of n becomes

$$\left[\left(-\frac{n-1}{2}y_1\right) - \left(\frac{n-3}{2}y_2\right) - \left(\frac{n-5}{2}y_3\right) - \dots\right.$$

$$- \left(3\,y_{\frac{n-5}{2}}\right) - \left(2\,y_{\frac{n-3}{2}}\right) - \left(y_{\frac{n-1}{2}}\right)$$

$$+ \left(y_{\frac{n+3}{2}}\right) + \left(2\,y_{\frac{n+5}{2}}\right) + \left(3\,y_{\frac{n+7}{2}}\right) + \dots$$

$$\left. + \left(\frac{n-5}{2}y_{n-2}\right) + \left(\frac{n-3}{2}y_{n-1}\right) + \left(\frac{n-1}{2}y_n\right)\right]$$

$$\div \left[\left(\frac{n-1}{2}\right)^2 + \left(\frac{n-3}{2}\right)^2 + \left(\frac{n-5}{2}\right)^2 + \dots\right.$$

$$+ 3^2 + 2^2 + 1^2 + 1^2 + 2^2 + 3^2 + \dots$$

$$\left. + \left(\frac{n-5}{2}\right)^2 + \left(\frac{n-3}{2}\right)^2 + \left(\frac{n-1}{2}\right)^2\right].$$

Let us call this expression (a).

Now the various mean annual increments as determined by the empirical process described in the first part of this note are

$$\frac{y_n - y_1}{n-1}, \quad \frac{y_{n-1} - y_2}{n-3}, \quad \frac{y_{n-2} - y_3}{n-5}, \dots,$$

$$\frac{y_{\frac{n+7}{2}} - y_{\frac{n-5}{2}}}{6}, \quad \frac{y_{\frac{n+5}{2}} - y_{\frac{n-3}{2}}}{4}, \quad \frac{y_{\frac{n+3}{2}} - y_{\frac{n-1}{2}}}{2}.$$

If we weight each one by the square of the time period and average, we shall have

$$\left[(n-1)^2\frac{y_n - y_1}{n-1} + (n-3)^2\frac{y_{n-1} - y_2}{n-3} + (n-5)^2\frac{y_{n-2} - y_3}{n-5}\right.$$

$$+ \dots + 6^2 \cdot \frac{y_{\frac{n+7}{2}} - y_{\frac{n-5}{2}}}{6} + 4^2 \cdot \frac{y_{\frac{n+5}{2}} - y_{\frac{n-3}{2}}}{4}$$

$$\left. + 2^2 \cdot \frac{y_{\frac{n+3}{2}} - y_{\frac{n-1}{2}}}{2}\right] \div \left[(n-1)^2 + (n-3)^2 + \dots + 4^2 + 2^2\right].$$

Canceling common factors this becomes

$$\left[-(n-1)y_1 - (n-3)y_2 - (n-5)y_3 - \dots\right.$$

$$- 6y_{\frac{n-5}{2}} - 4y_{\frac{n-3}{2}} - 2y_{\frac{n-1}{2}}$$

$$+ 2y_{\frac{n+3}{2}} + 4y_{\frac{n+5}{2}} + 6y_{\frac{n+7}{2}} + \dots$$

$$\left. + (n-5)\,y_{n-2} + (n-3)\,y_{n-1} + (n-1)\,y_n\right]$$

$$\div \left[(n-1)^2 + (n-3)^2 + (n-5)^2 + \dots + 6^2 + 4^2 + 2^2\right].$$

Dividing numerator and denominator by 2 and separating each term in the denominator into two equal parts we have

$$\left[-\left(\frac{n-1}{2}\right)y_1 - \left(\frac{n-3}{2}\right)y_2 - \left(\frac{n-5}{2}\right)y_3 - \dots\right.$$

$$- 3y_{\frac{n-5}{2}} - 2y_{\frac{n-3}{2}} - y_{\frac{n-1}{2}}$$

$$+ y_{\frac{n+3}{2}} + 2y_{\frac{n+5}{2}} + 3y_{\frac{n+7}{2}} + \dots$$

$$\left. + \left(\frac{n-5}{2}\right)y_{n-2} + \left(\frac{n-3}{2}\right)y_{n-1} + \left(\frac{n-1}{2}\right)y_n\right]$$

$$\div \left[\left(\frac{n-1}{2}\right)^2 + \left(\frac{n-3}{2}\right)^2 + \left(\frac{n-5}{2}\right)^2 + \dots\right.$$

$$+ 3^2 + 2^2 + 1^2 + 1^2 + 2^2 + 3^2 + \dots$$

$$\left. + \left(\frac{n-5}{2}\right)^2 + \left(\frac{n-3}{2}\right)^2 + \left(\frac{n-1}{2}\right)^2\right].$$

Designating the expression just secured by (b) we see that expression (a) equals expression (b) and the theorem with which we started is demonstrated. A similar proof may be developed for the cases where the number of items (n) is even instead of odd.

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[1] This figure (1,142,000 tons) represents the uniform annual increase in the line of secular trend fitted to the total *annual* pig-iron production for the years 1903–16. The uniform annual increase in the line of secular trend fitted to the data for the total *monthly* pig-iron production for the same period would be one-twelfth of 1,142,000 tons, or 95,200 tons. In the January issue of the REVIEW, p. 40, it was stated that "The linear trend, 1903–16, [fitted to the monthly data by the method of least squares] has a uniform annual increment of 95,200 tons." For this particular case, therefore, the method of computing the annual increment outlined above and the method of least squares give identical results.